

# Mixed Signal Oscilloscopes

## MSO4000 Series, DPO4000 Series Data Sheet



### Features & Benefits

#### Key Performance Specifications

- 1 GHz, 500 MHz, 350 MHz Bandwidth Models
- 4 Analog Channel Models
- 16 Digital Channels (MSO Series)
- Up to 5 GS/s Sample Rate on All Channels
- 10 Megapoint Record Length on All Channels
- >50,000 wfm/s Maximum Waveform Capture Rate
- Suite of Advanced Triggers

#### Ease of Use Features

- Wave Inspector® Controls provide Easy Navigation and Automated Search of Waveform Data
- 29 Automated Measurements, Waveform Histograms, and FFT Analysis for Simplified Waveform Analysis
- TekVPI® Probe Interface supports Active, Differential, and Current Probes for Automatic Scaling and Units
- 10.4 in. (264 mm) XGA Color Display
- Small Footprint and Lightweight – Only 5.4 in. (137 mm) deep and 11 lb. (5 kg)

#### Connectivity

- USB 2.0 Host Port on the Front Panel and Two on the Rear Panel for Quick and Easy Data Storage, Printing, and Connecting a USB Keyboard
- USB 2.0 Device Port on Rear Panel for Easy Connection to a PC or Direct Printing to a PictBridge®-compatible Printer
- Integrated 10/100 Ethernet Port for Network Connection and Video Out Port to Export the Oscilloscope Display to a Monitor or Projector

#### Optional Serial Triggering and Analysis

- Automated Serial Triggering, Decode, and Search Options for I<sup>2</sup>C, SPI, USB, CAN, LIN, FlexRay, RS-232/422/485/UART, and I<sup>2</sup>S/LJ/RJ/TDM

#### Mixed Signal Design and Analysis (MSO Series)

- Automated Triggering, Decode, and Search on Parallel Buses
- Per-channel Threshold Settings
- Multichannel Setup and Hold Triggering
- MagniVu™ High-speed Acquisition Provides 60.6 ps Fine Timing Resolution on Digital Channels

#### Optional Application Support

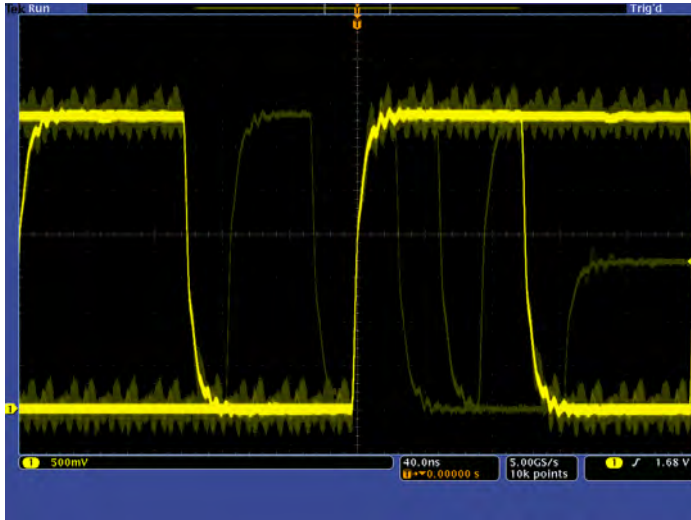
- Power Analysis
- HDTV and Custom Video Analysis

### Feature-rich Tools for Debugging Mixed Signal Designs

With the MSO/DPO4000 Mixed Signal Oscilloscope Series, you can analyze up to 20 analog and digital signals with a single instrument to quickly find and diagnose problems in complex designs. Bandwidths up to 1 GHz and a minimum of 5x oversampling on all channels ensure you have the performance you need to see fast-changing signal details. To capture long windows of signal activity while maintaining fine timing resolution, the MSO/DPO4000 offers a deep record length of 10M points standard on all channels.

With Wave Inspector® controls for rapid waveform navigation, automated serial and parallel bus analysis, and automated power analysis – the MSO/DPO4000 Oscilloscope Series from Tektronix provides the feature-rich tools you need to simplify and speed debug of your complex design.





Discover – Fast waveform capture rate - over 50,000 wfms/s - maximizes the probability of capturing elusive glitches and other infrequent events.

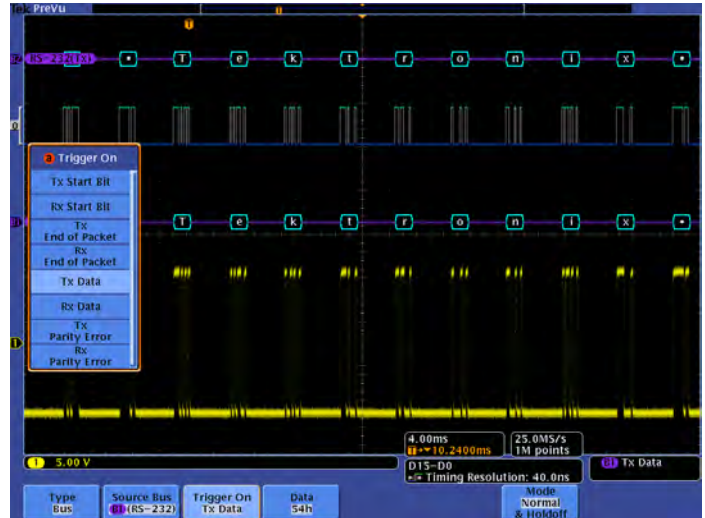
## Comprehensive Features Speed Every Stage of Debug

The MSO/DPO4000 Series offers a robust set of features to speed every stage of debugging your design – from quickly discovering an anomaly and capturing it, to searching your waveform record for the event and analyzing its characteristics and your device's behavior.

### Discover

To debug a design problem, first you must know it exists. Every design engineer spends time looking for problems in their design, a time-consuming and frustrating task without the right debug tools.

The MSO/DPO4000 Series offers the industry's most complete visualization of signals, providing fast insight into the real operation of your device. A fast waveform capture rate - greater than 50,000 waveforms per second - enables you to see glitches and other infrequent transients within seconds, revealing the true nature of device faults. A digital phosphor display with intensity grading shows the history of a signal's activity by intensifying areas of the signal that occur more frequently, providing a visual display of just how often anomalies occur.



Capture – Triggering on a specific transmit data packet going across an RS-232 bus. A complete set of triggers, including triggers for specific serial packet content, ensures you quickly capture your event of interest.

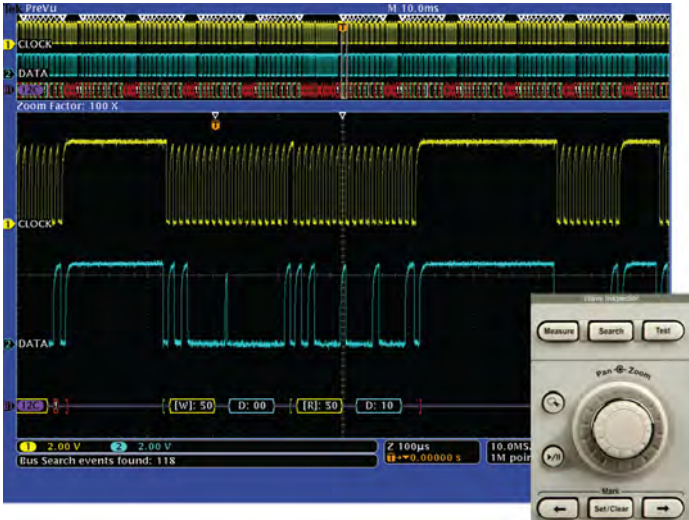
### Capture

Discovering a device fault is only the first step. Next, you must capture the event of interest to identify root cause.

The MSO/DPO4000 Series provides a complete set of triggers - including runt, logic, pulse width/glitch, setup/hold violation, serial packet, and parallel data - to help quickly find your event. With up to a 10M point record length, you can capture many events of interest, even thousands of serial packets, in a single acquisition for further analysis while maintaining high resolution to zoom in on fine signal details.

From triggering on specific packet content to automatic decode in multiple data formats, the MSO/DPO4000 Series provides integrated support for the industry's broadest range of serial buses – I<sup>2</sup>C, SPI, USB, CAN, LIN, FlexRay, RS-232/422/485/UART, and I<sup>2</sup>S/LJ/RJ/TDM. The ability to decode up to four serial and/or parallel buses simultaneously means you gain insight into system-level problems quickly.

To further help troubleshoot system-level interactions in complex embedded systems, the MSO4000 Series offers 16 digital channels in addition to its analog channels. Since the digital channels are fully integrated into the oscilloscope, you can trigger across all input channels, automatically time correlating all analog, digital, and serial signals. The MagniVu™ high-speed acquisition enables you to acquire fine signal detail (up to 60.6 ps resolution) around the trigger point for precision measurements. MagniVu is essential for making accurate timing measurements for setup and hold measurements, clock delay, signal skew, and glitch characterization.

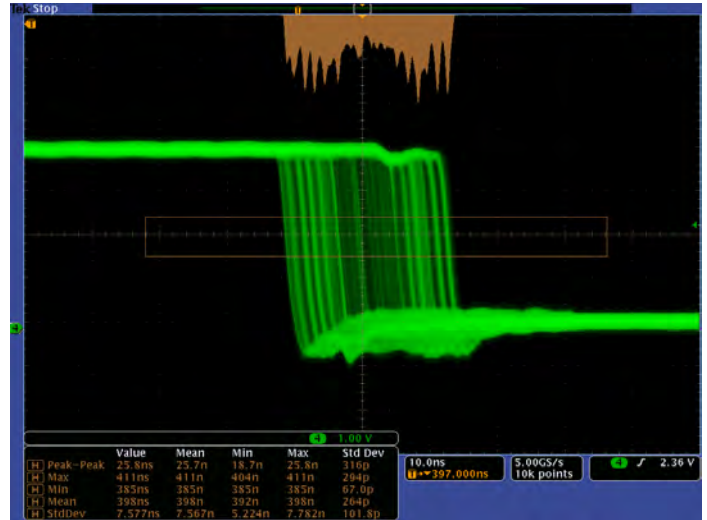


Search – I<sup>2</sup>C decode showing results from a Wave Inspector search for Address value 50. Wave Inspector controls provide unprecedented efficiency in viewing and navigating waveform data.

## Search

Finding your event of interest in a long waveform record can be time consuming without the right search tools. With today's record lengths pushing beyond a million data points, locating your event can mean scrolling through thousands of screens of signal activity.

The MSO/DPO4000 Series offers the industry's most comprehensive search and waveform navigation with its innovative Wave Inspector® controls. These controls speed panning and zooming through your record. With a unique force-feedback system, you can move from one end of your record to the other in just seconds. User marks allow you to mark any location that you may want to reference later for further investigation. Or, automatically search your record for criteria you define. Wave Inspector will instantly search your entire record, including analog, digital, and serial bus data. Along the way it will automatically mark every occurrence of your defined event so you can quickly move between events.



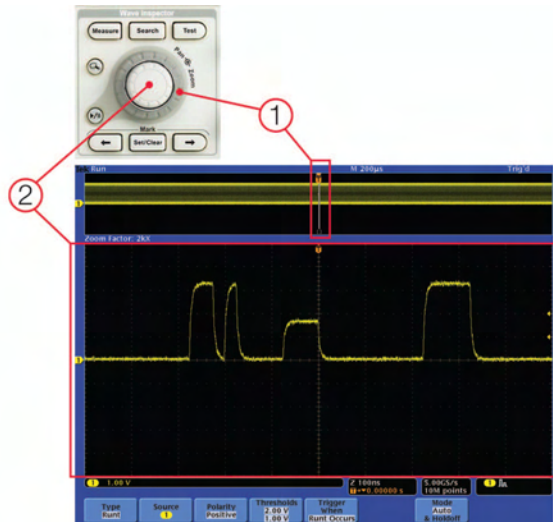
Analyze – Waveform histogram of a falling edge showing the distribution of edge position (jitter) over time. Included are numeric measurements made on the waveform histogram data. A comprehensive set of integrated analysis tools speeds verification of your design's performance.

## Analyze

Verifying that your prototype's performance matches simulations and meets the project's design goals requires analyzing its behavior. Tasks can range from simple checks of rise times and pulse widths to sophisticated power loss analysis and investigation of noise sources.

The MSO/DPO4000 Series offers a comprehensive set of integrated analysis tools including waveform- and screen-based cursors, 29 automated measurements, advanced waveform math including arbitrary equation editing, waveform histograms, FFT analysis, and trend plots for visually determining how a measurement is changing over time. Specialized application support for serial bus analysis, power supply design, and video design and development is also available.

For extended analysis, National Instrument's LabVIEW SignalExpress™ Tektronix Edition provides over 200 built-in functions including time and frequency domain analysis, limit testing, data logging, and customizable reports.



Wave Inspector controls provide unprecedented efficiency in viewing, navigating, and analyzing waveform data. Zip through your 10M point record by turning the outer pan control (1). Get from the beginning to end in seconds. See something of interest and want to see more details? Just turn the inner zoom control (2).

## Wave Inspector® Navigation and Search

A 10M point record length represents thousands of screens of information. The MSO/DPO4000 Series enables you to find your event in seconds with Wave Inspector, the industry's best tool for navigation and search.

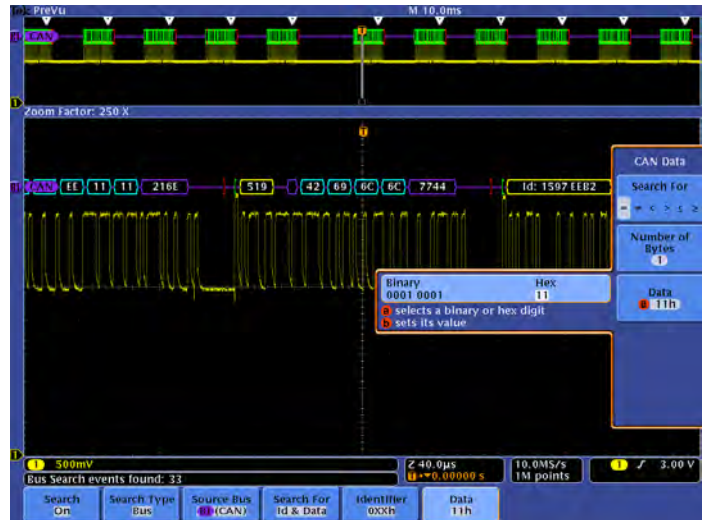
Wave Inspector offers the following innovative controls:

### Zoom/Pan

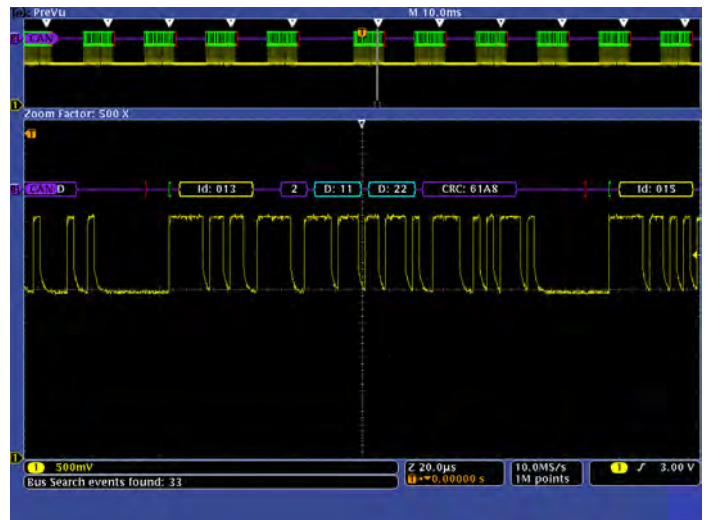
A dedicated, two-tier front-panel control provides intuitive control of both zooming and panning. The inner control adjusts the zoom factor (or zoom scale); turning it clockwise activates zoom and goes to progressively higher zoom factors, while turning it counterclockwise results in lower zoom factors and eventually turning zoom off. No longer do you need to navigate through multiple menus to adjust your zoom view. The outer control pans the zoom box across the waveform to quickly get to the portion of waveform you are interested in. The outer control also utilizes force feedback to determine how fast to pan on the waveform. The farther you turn the outer control, the faster the zoom box moves. Pan direction is changed by simply turning the control the other way.

### Play/Pause

A dedicated **Play/Pause** front-panel button scrolls the waveform across the display automatically while you look for anomalies or an event of interest. Playback speed and direction are controlled using the intuitive pan control. Once again, turning the control further makes the waveform scroll faster and changing direction is as simple as turning the control the other way.



Search step 1: You define what you would like to find.



Search step 2: Wave Inspector automatically searches through the record and marks each event with a hollow white triangle. You can then use the **Previous** and **Next** buttons to jump from one event to the next.

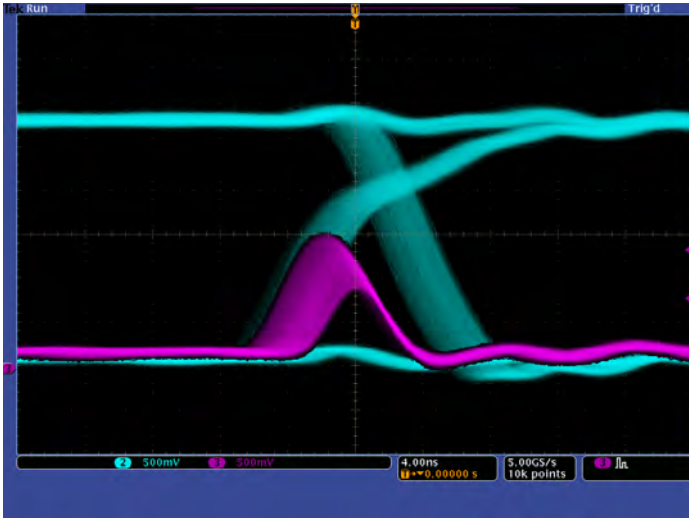
### User Marks

Press the **Set Mark** front-panel button to place one or more marks on the waveform. Navigating between marks is as simple as pressing the **Previous** (←) and **Next** (→) buttons on the front panel.

### Search Marks

The **Search** button allows you to automatically search through your long acquisition looking for user-defined events. All occurrences of the event are highlighted with search marks and are easily navigated to, using the front-panel **Previous** (←) and **Next** (→) buttons. Search types include edge, pulse width/glitch, runt, logic, setup and hold, rise/fall time parallel bus, and I<sup>2</sup>C, SPI, USB, CAN, LIN, FlexRay, RS-232/422/485/UART, and I<sup>2</sup>S/LJ/RJ/TDM packet content.





Digital phosphor technology enables greater than 50,000 wfms/s waveform capture rate and real-time intensity grading on the MSO/DPO4000 Series.

## Digital Phosphor Technology

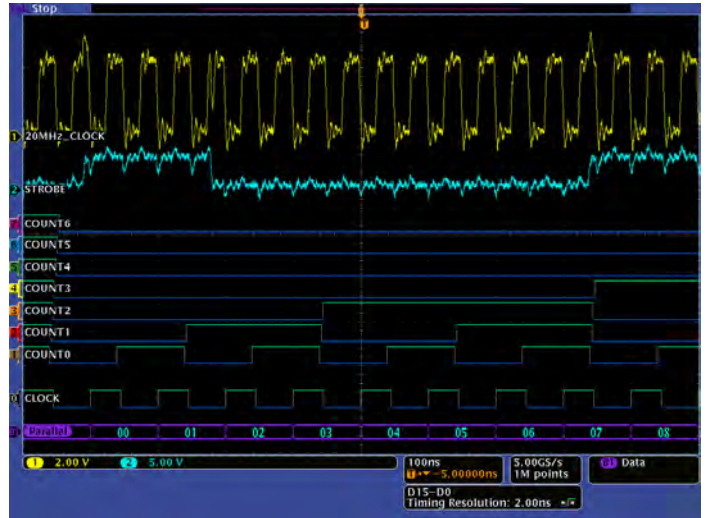
The MSO/DPO4000 Series' digital phosphor technology provides you with fast insight into the real operation of your device. Its fast waveform capture rate - greater than 50,000 wfms/s - gives you a high probability of quickly seeing the infrequent problems common in digital systems: runt pulses, glitches, timing issues, and more.

Waveforms are superimposed with one another and waveform points that occur more frequently are intensified. This quickly highlights the events that over time occur more often or, in the case of infrequent anomalies, occur less often.

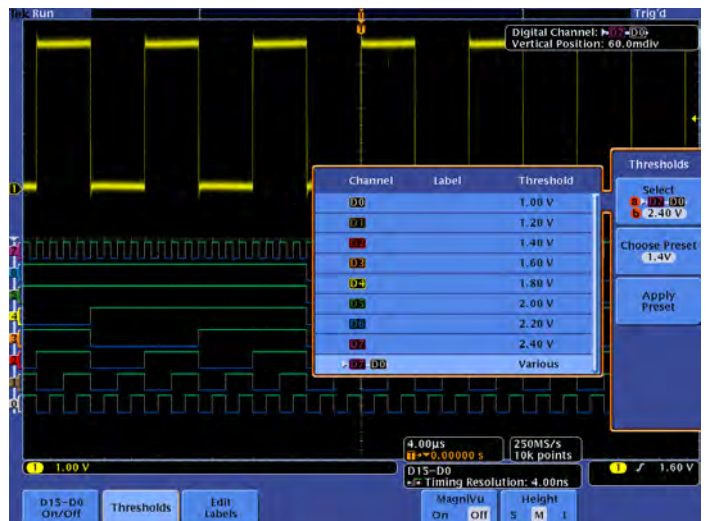
With the MSO/DPO4000 Series, you can choose infinite persistence or variable persistence, determining how long the previous waveform acquisitions stay on-screen. This allows you to determine how often an anomaly is occurring.

## Mixed Signal Design and Analysis (MSO Series)

The MSO4000 Series Mixed Signal Oscilloscopes provide 16 digital channels. These channels are tightly integrated into the oscilloscope's user interface, simplifying operation and making it possible to solve mixed-signal issues easily.



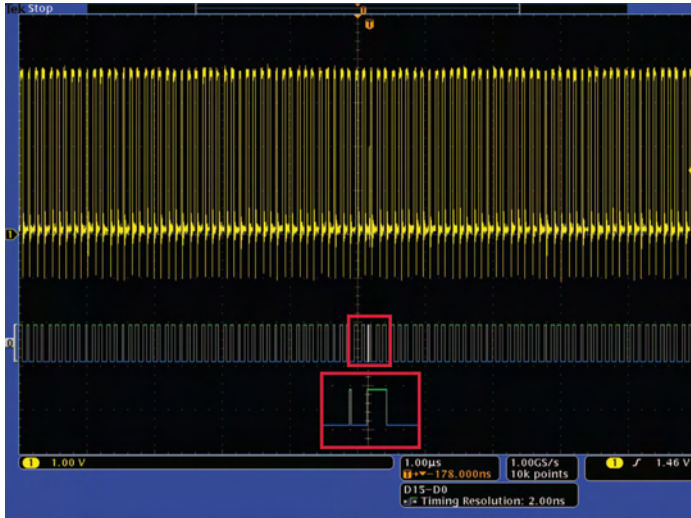
The MSO Series provides 16 integrated digital channels enabling you to view and analyze time-correlated analog and digital signals.



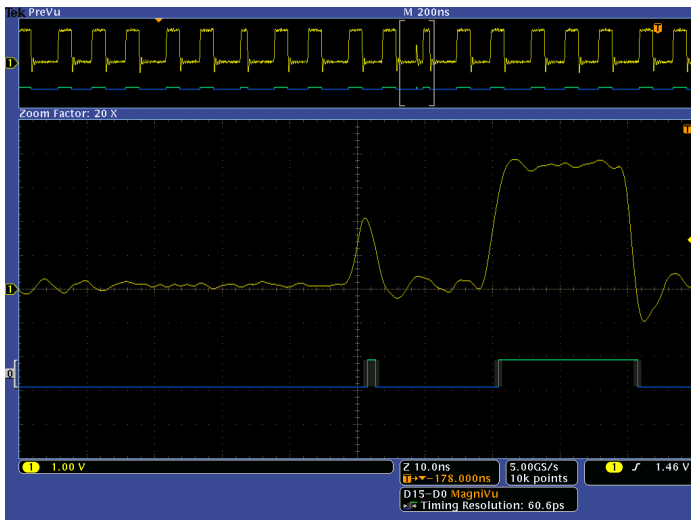
With the color-coded digital waveform display, groups are created by simply placing digital channels together on the screen, allowing the digital channels to be moved as a group. You can set threshold values for each channel, enabling support for up to 16 different logic families.

## Color-coded Digital Waveform Display

The MSO4000 Series has redefined the way you view digital waveforms. One common problem shared by both logic analyzers and mixed signal oscilloscopes is determining if data is a one or a zero when zoomed in far enough that the digital trace stays flat all the way across the display. The MSO4000 Series has color-coded digital traces, displaying ones in green and zeros in blue.



White edges indicate additional information is available by zooming in. As shown here, zooming in on the white edge reveals a hidden glitch.



The MagniVu high-resolution record provides 60.6 ps timing resolution, enabling you to make critical timing measurements on your digital waveforms.

The multiple transition detection hardware of the MSO4000 Series will show you a white edge on the display when the system detects multiple transitions. White edges indicate that more information is available by zooming in or acquiring at faster sampling rates. In most cases zooming in will reveal the pulse that was not viewable with the previous settings. If the white edge is still present after zooming in as far as possible, this indicates that increasing the sample rate on the next acquisition will reveal higher frequency information than the previous settings could acquire.



The P6516 MSO probe offers two eight-channel pods to simplify connecting to your device.

The MSO4000 Series simplifies channel setup by allowing you to group digital waveforms and enter waveform labels by using a USB keyboard. By simply placing digital waveforms next to each other, they form a group. Once a group is formed, you can position all the channels contained in that group collectively. This greatly reduces the normal setup time associated with positioning channels individually.

### MagniVu™ High-speed Acquisition

The main digital acquisition mode on the MSO4000 Series will capture up to 10M points at 500 MS/s (2 ns resolution). In addition to the main record, the MSO4000 provides an ultra high-resolution record called MagniVu which acquires 10,000 points at up to 16.5 GS/s (60.6 ps resolution). Both main and MagniVu waveforms are acquired on every trigger and can be switched between in the display at any time, running or stopped. MagniVu provides significantly finer timing resolution than comparable MSOs on the market, instilling confidence when making critical timing measurements on digital waveforms.

### P6516 MSO Probe

This unique probe design offers two eight-channel pods. Each channel ends with a probe tip featuring a recessed ground for simplified connection to the device under test. The coax on the first channel of each pod is colored blue making it easy to identify. The common ground uses an automotive-style connector making it easy to create custom grounds for connecting to the device under test. When connecting to square pins, the P6516 has an adapter that attaches to the probe head extending the probe ground flush with the probe tip so you can attach to a header. The P6516 offers outstanding electrical characteristics, applying only 3 pF of loading.



Triggering on a specific OUT Token packet on a USB full-speed serial bus. The yellow waveform is the D+ and the blue waveform is the D-. A bus waveform provides decoded packet content including Start, Sync, PID, Address, End Point, CRC, Data values, and Stop.

## Serial Triggering and Analysis (Optional)

On a serial bus, a single signal often includes address, control, data, and clock information. This can make isolating events of interest difficult. The MSO/DPO4000 Series offers a robust set of tools for debugging serial buses with automatic trigger, decode, and search for I<sup>2</sup>C, SPI, USB, CAN, LIN, FlexRay, RS-232/422/485/UART, and I<sup>2</sup>S/LJ/RJ/TDM.

### Serial Triggering

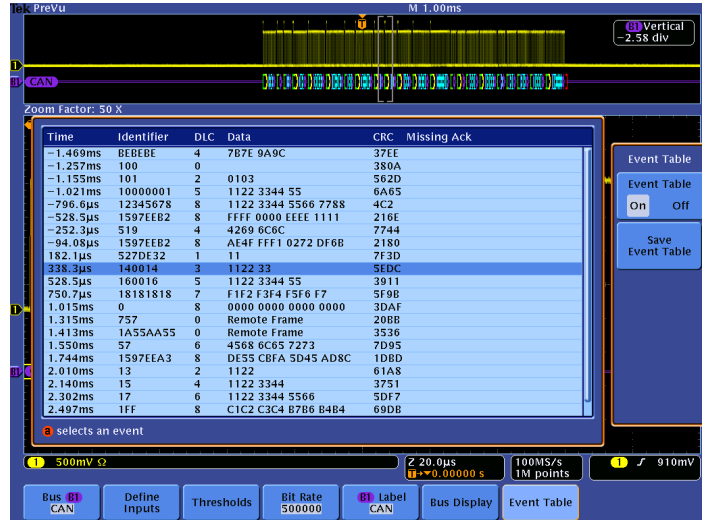
Trigger on packet content such as start of packet, specific addresses, specific data content, unique identifiers, etc. on popular serial interfaces such as I<sup>2</sup>C, SPI, USB, CAN, LIN, FlexRay, RS-232/422/485/UART, and I<sup>2</sup>S/LJ/RJ/TDM.

### Bus Display

Provides a higher-level, combined view of the individual signals (clock, data, chip enable, etc.) that make up your bus, making it easy to identify where packets begin and end and identifying subpacket components such as address, data, identifier, CRC, etc.

### Bus Decoding

Tired of having to visually inspect the waveform to count clocks, determine if each bit is a 1 or a 0, combine bits into bytes, and determine the hex



Event table showing decoded Identifier, DLC, DATA, and CRC for every CAN packet in a long acquisition.

value? Let the oscilloscope do it for you! Once you've set up a bus, the MSO/DPO4000 Series will decode each packet on the bus, and display the value in hex, binary, decimal (USB, LIN, and FlexRay only), signed decimal (I<sup>2</sup>S/LJ/RJ/TDM only), or ASCII (USB and RS-232/422/485/UART only) in the bus waveform.

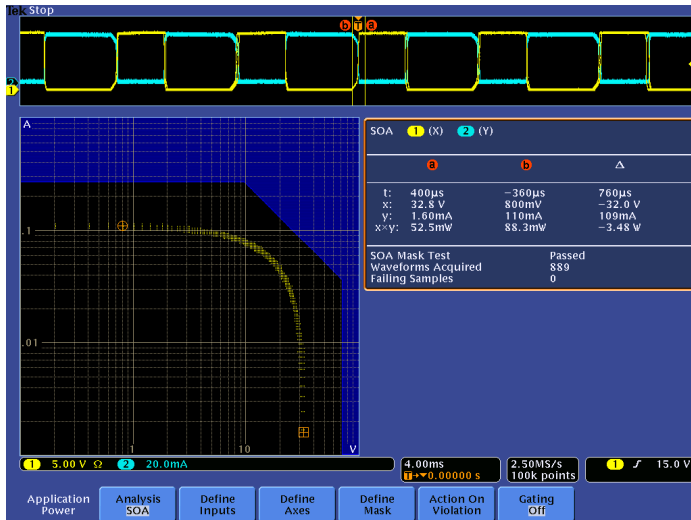
### Event Table

In addition to seeing decoded packet data on the bus waveform itself, you can view all captured packets in a tabular view much like you would see in a software listing. Packets are time stamped and listed consecutively with columns for each component (Address, Data, etc.).

### Search

Serial triggering is very useful for isolating the event of interest, but once you've captured it and need to analyze the surrounding data, what do you do? In the past, users had to manually scroll through the waveform counting and converting bits and looking for what caused the event. With the MSO/DPO4000 Series, you can have the oscilloscope automatically search through the acquired data for user-defined criteria including serial packet content. Each occurrence is highlighted by a search mark. Rapid navigation between marks is as simple as pressing the **Previous** (←) and **Next** (→) buttons on the front panel.

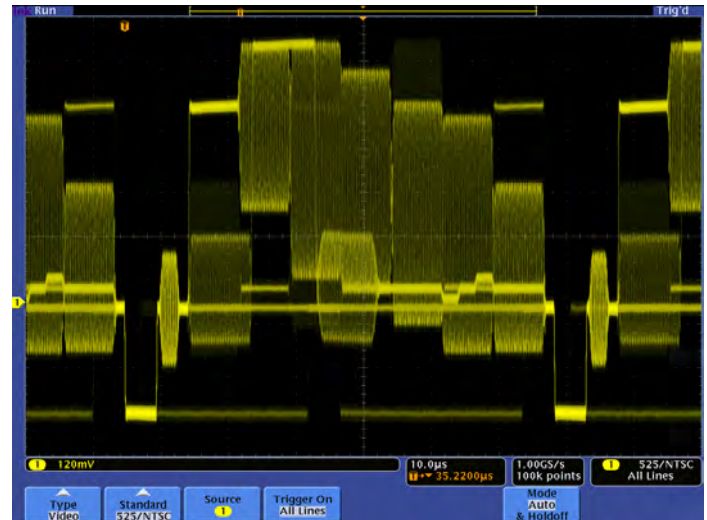




Safe operating area measurement. Automated power measurements enable quick and accurate analysis of common power parameters.

## Power Analysis (Optional)

Ever increasing consumer demand for longer battery-life devices and for green solutions that consume less power require power-supply designers to characterize and minimize switching losses to improve efficiency. In addition, the supply's power levels, output purity, and harmonic feedback into the power line must be characterized to comply with national and regional power quality standards. Historically, making these and many other power measurements on an oscilloscope has been a long, manual, and tedious process. The MSO/DPO4000 Series optional power analysis tools greatly simplify these tasks, enabling quick and accurate analysis of power quality, switching loss, harmonics, safe operating area (SOA), modulation, ripple, and slew rate (di/dt, dv/dt). Completely integrated into the oscilloscope, the power analysis tools provide automated, repeatable power measurements with a touch of a button; no external PC or complex software setup is required.



Viewing an NTSC video signal. Notice the intensity-graded view provided by the DPO's ability to represent time, amplitude, and distribution of amplitude over time.

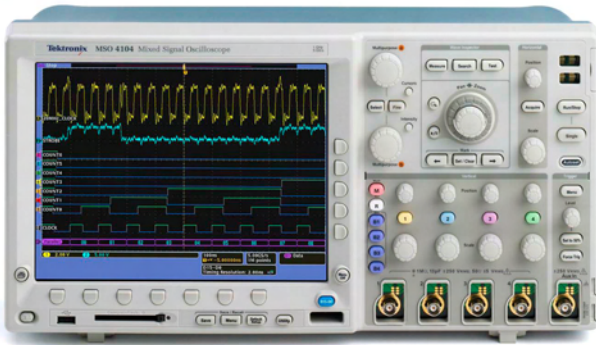
## Video Design and Development

Many video engineers have remained loyal to analog oscilloscopes, believing the intensity gradations on an analog display are the only way to see certain video waveform details. The MSO/DPO4000 Series fast waveform capture rate, coupled with its intensity-graded view of the signal, provides the same information-rich display as an analog oscilloscope, but with much more detail and all the benefits of digital scopes.

Standard features such as IRE and mV graticules, holdoff by fields, video polarity, and an Autoset smart enough to detect video signals, make the MSO/DPO4000 Series the easiest to use oscilloscope on the market for video applications. And with up to a 1 GHz bandwidth and four analog inputs, the MSO/DPO4000 Series provides ample performance for analog and digital video use.

The MSO/DPO4000 Series video functionality is further extended with the optional DPO4VID video application module. DPO4VID provides the industry's most complete suite of HDTV and custom (nonstandard) video triggers.





The MSO/DPO4000 is designed to make your work easier. The large, high-resolution display shows intricate signal details. Dedicated front-panel controls simplify operation. A USB host port on the front panel allows you to easily transfer screenshots, instrument settings, and waveform data to a USB thumb drive.

## Designed to Make Your Work Easier

### Large, High-resolution Display

The MSO/DPO4000 Series features a 10.4 inch (264 mm) XGA color display for seeing intricate signal details.

### Dedicated Front-panel Controls

Per-channel vertical controls provide simple and intuitive operation. No longer do you need to share one set of vertical controls across all four channels.

### Connectivity

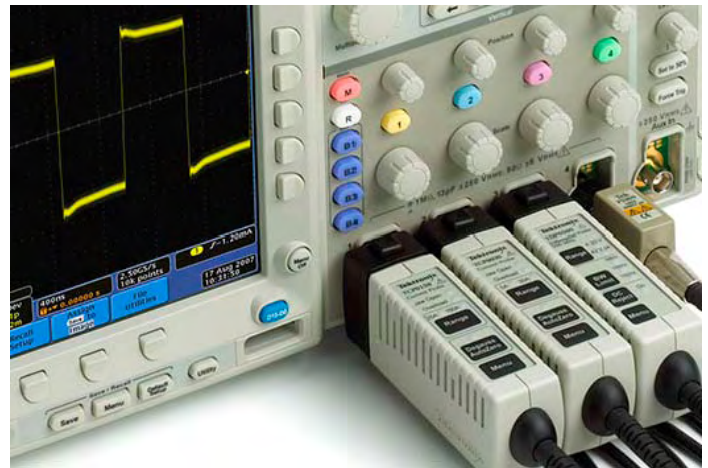
A USB host port on the front panel enables easy transfer of screenshots, instrument settings, and waveform data to a USB thumb drive. The rear panel contains two additional USB host ports and a USB device port for controlling the oscilloscope remotely from a PC or for connecting a USB keyboard. The USB device port can also be used to print directly to a PictBridge®-compatible printer. An integrated 10/100 Ethernet port enables easy connection to networks and a Video Out port allows the oscilloscope display to be exported to an external monitor or projector.

### Compact Form Factor

A compact, portable form factor allows the MSO/DPO4000 Series to be easily moved between labs and, with a depth of just 5.4 inches (137 mm), it saves you valuable space on your test bench.



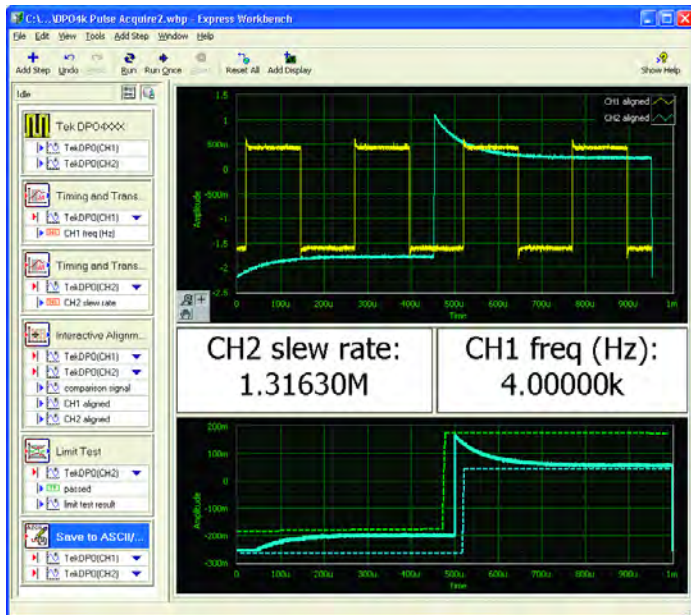
The MSO/DPO4000 Series' compact form factor frees up valuable space on your bench or desktop.



TekVPI probe interface simplifies connecting your probes to the oscilloscope.

### TekVPI® Probe Interface

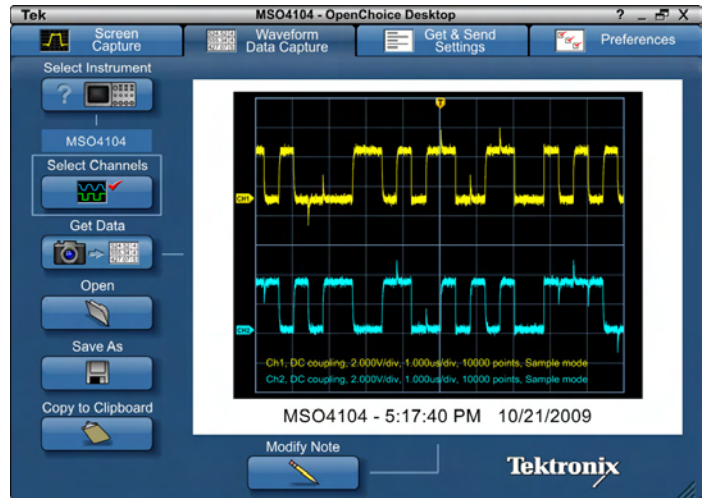
The TekVPI probe interface sets the standard for ease of use in probing. TekVPI probes feature status indicators and controls, as well as a probe menu button right on the comp box itself. This button brings up a probe menu on the oscilloscope display with all relevant settings and controls for the probe. The TekVPI interface enables direct attachment of current probes without requiring a separate power supply. TekVPI probes can be controlled remotely through USB, GPIB, or Ethernet, enabling more versatile solutions in ATE environments.



NI LabVIEW SignalExpress™ Tektronix Edition is a fully interactive measurement acquisition and analysis software developed jointly with National Instruments and optimized for the MSO/DPO Series.

### Extended Analysis

Acquiring data and measurements from the MSO/DPO4000 Series is as simple as connecting a USB cable from the oscilloscope to your PC. Key software applications - NI LabVIEW SignalExpress™ Tektronix Edition LE, OpenChoice® Desktop, and Microsoft Excel and Word toolbars - are included standard with each oscilloscope to enable fast and easy direct communication with your Windows PC.



OpenChoice® Desktop software enables seamless connection between the oscilloscope and your PC.

NI LabVIEW SignalExpress Tektronix Edition LE enables you to instantly acquire, generate, analyze, compare, import, and save measurement data and signals using an intuitive drag-and-drop user interface that does not require any programming. The optional Professional Version offers over 200 built-in functions that provide additional signal processing, advanced analysis, sweeping, limit testing, and user-defined step capabilities.

For simple tasks, the included OpenChoice Desktop enables fast and easy communication between the oscilloscope and your PC through USB or LAN for transferring settings, waveforms, and screen images.

## Characteristics

### Vertical System Analog Channels

Characteristic	DPO4034 MSO4034	DPO4054 MSO4054	DPO4104 MSO4104
Input Channels	4	4	4
Analog Bandwidth (–3 dB) 5 mV/div - 1 V/div	350 MHz	500 MHz	1 GHz
Calculated Rise Time 5 mV/div (typical)	1 ns	700 ps	350 ps
Hardware Bandwidth Limits	20 MHz or 250 MHz		
Input Coupling	AC, DC, GND		
Input Impedance	1 M $\Omega$ $\pm$ 1%, 50 $\Omega$ $\pm$ 1%		
Input Sensitivity, 1 M $\Omega$	1 mV/div to 10 V/div		
Input Sensitivity, 50 $\Omega$	1 mV/div to 1 V/div		
Vertical Resolution	8 bits (11 bits with Hi Res)		
Max Input Voltage, 1 M $\Omega$	250 V <sub>RMS</sub> with peaks $\leq$ $\pm$ 400 V		
Max Input Voltage, 50 $\Omega$	5 V <sub>RMS</sub> with peaks < $\pm$ 20 V		
DC Gain Accuracy	$\pm$ 1.5% with offset set to 0 V		
Channel-to-Channel Isolation	$\geq$ 100:1 at $\leq$ 100 MHz and $\geq$ 30:1 at >100 MHz up to the rated bandwidth for any two channels having equal volts/div settings		

### Offset Range

Range	1 M $\Omega$	50 $\Omega$ , 75 $\Omega$
1 mV/div to 50 mV/div	$\pm$ 1 V	$\pm$ 1 V
50.5 mV/div to 99.5 mV/div	$\pm$ 0.5 V	$\pm$ 0.5 V
100 mV/div to 500 mV/div	$\pm$ 10 V	$\pm$ 10 V
505 mV/div to 995 mV/div	$\pm$ 5 V	$\pm$ 5 V
1 V/div to 5 V/div	$\pm$ 100 V	$\pm$ 5 V
5.05 V/div to 10 V/div	$\pm$ 50 V	NA

### Vertical System Digital Channels

Characteristic	All MSO4000 Models
Input Channels	16 Digital (D15 - D0)
Thresholds	Per-channel Thresholds
Threshold Selections	TTL, CMOS, ECL, PECL, User Defined
User-defined Threshold Range	+5 to –2 V
Maximum Input Voltage	$\pm$ 15 V
Threshold Accuracy	$\pm$ (100 mV + 3% of threshold setting)
Input Dynamic Range	6 V <sub>pp</sub> centered around the threshold
Minimum Voltage Swing	500 mV
Input Impedance	20 k $\Omega$
Probe Loading	3 pF
Vertical Resolution	1 bit

### Horizontal System Analog Channels

Characteristic	DPO4034 MSO4034	DPO4054 MSO4054	DPO4104 MSO4104
Maximum Sample Rate (All channels)	2.5 GS/s	2.5 GS/s	5 GS/s
Maximum Record Length (All channels)	10M points		
Maximum Duration at Highest Sample Rate (All channels)	4 ms	4 ms	2 ms
Time Base Range	1 ns to 1,000 s		400 ps to 1,000 s
Time Base Delay	–10 divisions to 5000 s		
Time Range			
Channel-to-Channel Deskew Range	$\pm$ 100 ns		
Time Base Accuracy	$\pm$ 5 ppm over any $\geq$ 1 ms interval		

### Horizontal System Digital Channels

Characteristic	All MSO4000 Models
Maximum Sample Rate (Main)	500 MS/s (2 ns resolution)
Maximum Record Length (Main)	10M points
Maximum Sample Rate (MagnaVu)	16.5 GS/s (60.6 ps resolution)
Maximum Record Length (MagnaVu)	10k points centered around the trigger
Minimum Detectable Pulse Width	1.5 ns
Channel-to-Channel Skew	500 ps typical



**Trigger System**

Characteristic	Description
Main Trigger Modes	Auto, Normal, and Single
Trigger Coupling	DC, AC, HF reject (attenuates >50 kHz), LF reject (attenuates <50 kHz), noise reject (reduces sensitivity)
Trigger Holdoff Range	20 ns to 8 s

**Trigger Sensitivity**

Characteristic	Description
Internal DC Coupled	0.4 div from DC to 50 MHz, increasing to 1 div at rated bandwidth
External (Auxiliary Input)	200 mV from DC to 50 MHz increasing to 500 mV at 250 MHz

**Trigger Level Range**

Characteristic	Description
Any Channel	±8 divisions from center of screen
External (Auxiliary Input)	±8 V

**Trigger Modes**

Mode	Description
Edge	Positive or negative slope on any channel or front-panel auxiliary input. Coupling includes DC, AC, HF reject, LF reject, and noise reject
Sequence (B-trigger)	Trigger Delay by Time – 4 ns to 8 s. Or Trigger Delay by Events – 1 to 9,999,999 events
Pulse Width	Trigger on width of positive or negative pulses that are >, <, =, or ≠ a specified period of time
Runt	Trigger on a pulse that crosses one threshold but fails to cross a second threshold before crossing the first again
Logic	Trigger when any logical pattern of channels goes false or stays true for specified period of time. Any input can be used as a clock to look for the pattern on a clock edge. Pattern (AND, OR, NAND, NOR) specified for all analog and digital input channels defined as High, Low, or Don't Care
Setup and Hold	Trigger on violations of both setup time and hold time between clock and data present on any of the input channels
Rise/Fall Time	Trigger on pulse edge rates that are faster or slower than specified. Slope may be positive, negative, or either
Video	Trigger on all lines, odd, even, or all fields on NTSC, PAL, and SECAM video signals
Extended Video (Optional)	Trigger on 480p/60, 576p/50, 720p/30, 720p/50, 720p/60, 875i/60, 1080i/50, 1080i/60, 1080p/24, 1080p/24sF, 1080p/25, 1080p/30, 1080p/50, 1080p/60, and custom bi-level and tri-level sync video standards
I <sup>2</sup> C (Optional)	Trigger on Start, Repeated Start, Stop, Missing ACK, Address (7 or 10 bit), Data, or Address and Data on I <sup>2</sup> C buses up to 10 Mb/s
SPI (Optional)	Trigger on SS, MOSI, MISO, or MOSI and MISO on SPI buses up to 10.0 Mb/s
USB (Optional)	<p>Low Speed: Trigger on Sync, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error.</p> <p>Token packet trigger – Any token type, SOF, OUT, IN, SETUP; Address can be specified for Any Token, OUT, IN, and SETUP token types. Address can be further specified to trigger on ≤, &lt;, =, &gt;, ≥, ≠ a particular value, or inside or outside of a range. Frame number can be specified for SOF token using binary, hex, unsigned decimal and don't care digits.</p> <p>Data packet trigger – Any data type, DATA0, DATA1; Data can be further specified to trigger on ≤, &lt;, =, &gt;, ≥, ≠ a particular data value, or inside or outside of a range.</p> <p>Handshake packet trigger – Any handshake type, ACK, NAK, STALL.</p> <p>Special packet trigger – Any special type, Reserved.</p> <p>Error trigger – PID Check, CRC5 or CRC16, Bit Stuffing.</p> <p>Full Speed: Trigger on Sync, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error.</p> <p>Token packet trigger – Any token type, SOF, OUT, IN, SETUP; Address can be specified for Any Token, OUT, IN, and SETUP token types. Address can be further specified to trigger on ≤, &lt;, =, &gt;, ≥, ≠ a particular value, or inside or outside of a range. Frame number can be specified for SOF token using binary, hex, unsigned decimal and don't care digits.</p> <p>Data packet trigger – Any data type, DATA0, DATA1; Data can be further specified to trigger on ≤, &lt;, =, &gt;, ≥, ≠ a particular data value, or inside or outside of a range.</p> <p>Handshake packet trigger – Any handshake type, ACK, NAK, STALL.</p> <p>Special packet trigger – Any special type, PRE, Reserved.</p> <p>Error trigger – PID Check, CRC5 or CRC16, Bit Stuffing.</p> <p>High Speed: Trigger on edge. High Speed support only available on MSO4104 and DPO4104 models.</p>
CAN (Optional)	Trigger on Start of Frame, Frame Type (data, remote, error, overload), Identifier (standard or extended), Data, Identifier and Data, End of Frame, Missing ACK, or Bit Stuffing Error on CAN signals up to 1 Mb/s. Data can be further specified to trigger on ≤, <, =, >, ≥, or ≠ a specific data value. User-adjustable sample point is set to 50% by default
LIN (Optional)	Trigger on Sync, Identifier, Data, Identifier and Data, Wakeup Frame, Sleep Frame, Errors such as Sync, Parity, or Checksum Errors up to 1 Mb/s (by LIN definition, 20 kb/s)
FlexRay (Optional)	Trigger on Start of Frame, Type of Frame (Normal, Payload, Null, Sync, Startup), Identifier, Cycle Count, Complete Header Field, Data, Identifier and Data, End of Frame or Errors such as Header CRC, Trailer CRC, Null Frame, Sync Frame, or Startup Frame Errors
RS-232/422/485/UART (Optional)	Trigger on Tx Start Bit, Rx Start Bit, Tx End of Packet, Rx End of Packet, Tx Data, Rx Data, Tx Parity Error, and Rx Parity Error up to 10 Mb/s
I <sup>2</sup> S/LJ/RJ/TDM (Optional)	<p>Trigger on Word Select, Frame Sync, or Data. Data can be further specified to trigger on ≤, &lt;, =, &gt;, ≥, ≠ a specific data value, or inside or outside of a range</p> <p>Maximum data rate for I<sup>2</sup>S/LJ/RJ is 12.5 Mb/s</p> <p>Maximum data rate for TDM is 25 Mb/s</p>
Parallel (Available on MSO models only)	Trigger on a parallel bus data value. Parallel bus can be from 1 to 16 bits in size. Binary and Hex radices are supported

**Acquisition Modes**

Mode	Description
Sample	Acquire sampled values
Peak Detect	Captures glitches as narrow as 2 ns at all sweep speeds
Averaging	From 2 to 512 waveforms included in average
Envelope	Min-max envelope reflecting Peak Detect data over multiple acquisitions
Hi Res	Real-time boxcar averaging reduces random noise and increases vertical resolution
Roll	Scrolls waveforms right to left across the screen at sweep speeds slower than or equal to 40 ms/div

**Waveform Measurements**

Measurement	Description
Cursors	Waveform and Screen
Automatic Measurements	29, of which up to four can be displayed on-screen at any one time. Measurements include: Period, Frequency, Delay, Rise Time, Fall Time, Positive Duty Cycle, Negative Duty Cycle, Positive Pulse Width, Negative Pulse Width, Burst Width, Phase, Positive Overshoot, Negative Overshoot, Peak-to-Peak, Amplitude, High, Low, Max, Min, Mean, Cycle Mean, RMS, Cycle RMS, Positive Pulse Count, Negative Pulse Count, Rising Edge Count, Falling Edge Count, Area and Cycle Area
Measurement Statistics	Mean, Min, Max, Standard Deviation
Reference Levels	User-definable reference levels for automatic measurements can be specified in either percent or units
Gating	Isolate the specific occurrence within an acquisition to take measurements on, using either the screen, or waveform cursors
Waveform Histogram	A waveform histogram provides an array of data values representing the total number of hits inside of a user-defined region of the display. A waveform histogram is both a visual graph of the hit distribution as well as a numeric array of values that can be measured. Sources – Channel 1, Channel 2, Channel 3, Channel 4, Ref 1, Ref 2, Ref 3, Ref 4, Math Types – Vertical, Horizontal
Waveform Histogram Measurements	Waveform Count, Hits in Box, Peak Hits, Median, Max, Min, Peak-to-Peak, Mean, Standard Deviation, Sigma 1, Sigma 2, Sigma 3

**Power Measurements (Optional)**

Measurement	Description
Power Quality Measurements	$V_{RMS}$ , $V_{Crest\ Factor}$ , Frequency, $I_{RMS}$ , $I_{Crest\ Factor}$ , True Power, Apparent Power, Reactive Power, Power Factor, Phase Angle
Switching Loss Measurements	Power Loss: $T_{on}$ , $T_{off}$ , Conduction, Total Energy Loss: $T_{on}$ , $T_{off}$ , Conduction, Total
Harmonics	THD-F, THD-R, RMS measurements Graphical and table displays of harmonics Test to IEC61000-3-2 Class A and MIL-STD-1399
Ripple Measurements	$V_{ripple}$ and $I_{ripple}$
Modulation Analysis	Graphical display of +Pulse Width, –Pulse Width, Period, Frequency, +Duty Cycle, and –Duty Cycle modulation types
Safe Operating Area	Graphical display and mask testing of switching device safe operating area measurements
dV/dt and dI/dt Measurements	Cursor measurements of slew rate

**Waveform Math**

Characteristic	Description
Arithmetic	Add, subtract, multiply, and divide waveforms
Math Functions	Integrate, Differentiate, FFT
FFT	Spectral magnitude. Set FFT Vertical Scale to Linear RMS or dBV RMS, and FFT Window to Rectangular, Hamming, Hanning, or Blackman-Harris
Advanced Math	Define extensive algebraic expressions including waveforms, reference waveforms, math functions (FFT, Intg, Diff, Log, Exp, Sqrt, Sine, Cosine, Tangent), scalars, up to two user-adjustable variables and results of parametric measurements (Period, Freq, Delay, Rise, Fall, PosWidth, NegWidth, BurstWidth, Phase, PosDutyCycle, NegDutyCycle, PosOverShoot, NegOverShoot, PeakPeak, Amplitude, RMS, CycleRMS, High, Low, Max, Min, Mean, CycleMean, Area, CycleArea, and trend plots), e.g., $(Intg(Ch1 - Mean(Ch1)) \times 1.414 \times VAR1)$

## Software

Software	Description
NI LabVIEW SignalExpress Tektronix Edition LE	A fully interactive measurement software environment optimized for the MSO/DPO4000 Series, enables you to instantly acquire, generate, analyze, compare, import, and save measurement data and signals using an intuitive drag-and-drop user interface that does not require any programming. Standard MSO/DPO4000 Series support for acquiring, controlling, viewing, and exporting your live signal data is permanently available through the software. The full version (SIGEXPT) adds additional signal processing, advanced analysis, mixed signal, sweeping, limit testing, and user-defined step capabilities and is available for a 30-day trial period standard with each instrument.
OpenChoice® Desktop	Enables fast and easy communication between a Windows PC and the MSO/DPO4000 Series, using USB or LAN. Transfer and save settings, waveforms, measurements, and screen images. Included Word and Excel toolbars automate the transfer of acquisition data and screen images from the oscilloscope into Word and Excel for quick reporting or further analysis.
IVI Driver	Provides a standard instrument programming interface for common applications such as LabVIEW, LabWindows/CVI, Microsoft .NET and MATLAB.
eScope	Enables control of the MSO/DPO4000 Series over a network connection through a standard web browser. Simply enter the IP address or network name of the oscilloscope and a web page will be served to the browser.

## Display Characteristics

Characteristic	Description
Display Type	10.4 in. (264 mm) liquid-crystal TFT color display
Display Resolution	1,024 horizontal × 768 vertical pixels (XGA)
Waveform Styles	Vectors, Dots, Variable Persistence, Infinite Persistence
Graticules	Full, Grid, Cross Hair, Frame, IRE, and mV
Format	YT and simultaneous XY/YT
Waveform Capture Rate	>50,000 wfms/s

## Input/Output Ports

Port	Description
CompactFlash Drive	Front-panel access (Type 1)
USB 2.0 Full-speed Host Port	Supports USB mass storage devices, printers and keyboard. Two ports available on rear panel and one on front panel
USB 2.0 High-speed Device Port	Rear-panel connector allows for communication/control of oscilloscope through USBTMC or GPIB with a TEK-USB-488, and direct printing to all PictBridge-compatible printers
LAN Port	RJ-45 connector, supports 10/100Base-T
XGA Video Port	DB-15 female connector, connect to show the oscilloscope display on an external monitor or projector
Auxiliary Input	Front-panel BNC connector. Input Impedance 1 MΩ. Max input 250 V <sub>RMS</sub> with peaks ±400 V
Probe Compensator Output	Front-panel pins Amplitude: 2.5 V Frequency: 1 kHz
Trigger Out	Rear-panel BNC connector, provides a positive polarity pulse when the oscilloscope triggers
Kensington Lock	Rear-panel security slot connects to standard Kensington lock

## Power Source

Characteristic	Description
Power Source Voltage	100 to 240 V ±10%
Power Source Frequency	47 to 66 Hz (90 to 264 V) 360 to 440 Hz (100 to 132 V)
Power Consumption	250 W maximum

## Physical Characteristics

Dimensions	mm	in.
Height	229	9.0
Width	439	17.3
Depth	137	5.4
Weight	kg	lb.
Net	5	11
Shipping	9.5	22
Rackmount Configuration	5U	
Cooling Clearance	2 in. (51 mm) required on left side and rear of instrument	

## Environmental

Characteristic	Description
Temperature	
Operating	0 °C to +50 °C
Nonoperating	-20 °C to +60 °C
Humidity	
Operating	High: 40 °C to 50 °C, 10% to 60% Relative Humidity Low: 0 °C to 40 °C, 10% to 90% Relative Humidity
Nonoperating	High: 40 °C to 60 °C, 5% to 60% Relative Humidity Low: 0 °C to 40 °C, 5% to 90% Relative Humidity
Altitude	
Operating	3,000 meters (9,843 feet)
Nonoperating	12,000 meters (39,370 feet)
Random Vibration	
Operating	0.31 G <sub>RMS</sub> from 5 to 500 Hz, 10 minutes each axis, 3 axes, 30 minutes total
Nonoperating	2.46 G <sub>RMS</sub> from 5 to 500 Hz, 10 minutes each axis, 3 axes, 30 minutes total
Regulatory	
Electromagnetic Compatibility	89/336/EEC
Safety	UL61010-1, Second Edition; CSA61010-1 Second Edition, EN61010-1:2001; IEC 61010-1:2001



## Ordering Information

### MSO/DPO4000 Family

Model	Description
<b>DPO4000 Models</b>	
DPO4034	350 MHz, 2.5 GS/s, 10M record length, 4-channel digital phosphor oscilloscope
DPO4054	500 MHz, 2.5 GS/s, 10M record length, 4-channel digital phosphor oscilloscope
DPO4104	1 GHz, 5 GS/s, 10M record length, 4-channel digital phosphor oscilloscope
<b>MSO4000 Models</b>	
MSO4034	350 MHz, 2.5 GS/s, 10M record length, 4+16 channel mixed signal oscilloscope
MSO4054	500 MHz, 2.5 GS/s, 10M record length, 4+16 channel mixed signal oscilloscope
MSO4104	1 GHz, 5 GS/s, 10M record length, 4+16 channel mixed signal oscilloscope

**All Models Include:** One P6139A 500 MHz, 10x Passive Probe per Analog Channel, Front Cover (200-4908-xx), User Manual (071-2121-xx), Documentation CD (063-4022-xx), OpenChoice® Desktop Software, NI LabVIEW SignalExpress™ Tektronix Edition LE Software, Calibration certificates document measurement traceability to National Metrology Institute(s) – the Quality System this product is manufactured in is ISO9001 registered, power cord, accessory bag (016-1967-xx) and a three-year warranty. Please specify power plug and manual version when ordering.

**MSO Models also Include:** One P6516 16-channel logic probe and a logic probe accessory kit (020-2662-xx).

### Application Modules

Module	Description
DPO4AUDIO	Audio Serial Triggering and Analysis Module. Enables triggering on packet level information on I <sup>2</sup> S, LJ, RJ, and TDM audio buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time stamp information. Probing – I <sup>2</sup> S, LJ, RJ, TDM: Single ended.
DPO4AUTO	Automotive Serial Triggering and Analysis Module. Enables triggering on packet level information on CAN and LIN buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time stamp information. Probing – LIN: Single ended; CAN: Single ended or differential.
DPO4AUTOMAX	Extended Automotive Serial Triggering and Analysis Module. Enables triggering on packet level information on CAN, LIN, and FlexRay buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, packet decode tables with time stamp information, and eye diagram analysis software. Probing – LIN: Single ended; CAN, FlexRay: Single ended or differential.
DPO4COMP	Computer Serial Triggering and Analysis Module. Enables triggering on packet level information on RS-232/422/485/UART buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time stamp information. Probing – RS-232/422/485/UART: Single ended.
DPO4EMBD	Embedded Serial Triggering and Analysis Module. Enables triggering on packet level information on I <sup>2</sup> C and SPI buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time stamp information. Probing – I <sup>2</sup> C, SPI: Single ended.
DPO4USB	USB Serial Triggering and Analysis Module. Enables triggering on packet level content for Low-speed and Full-speed USB serial buses. Also enables analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time stamp information for Low-speed, Full-speed, and High-speed USB serial buses. Probing – Low Speed, Full Speed: Single ended or differential; High Speed: Differential. USB High Speed supported only on MSO4104 and DPO4104 models.
DPO4PWR	Power Analysis Application Module. Enables quick and accurate analysis of power quality, switching loss, harmonics, safe operating area (SOA), modulation, ripple, and slew rate (dI/dt, dV/dt).
DPO4VID	HDTV and Custom (nonstandard) Video Triggering Module.

## Instrument Options

### Power Plug Options

Option	Description
Opt. A0	North America
Opt. A1	Universal Euro
Opt. A2	United Kingdom
Opt. A3	Australia
Opt. A5	Switzerland
Opt. A6	Japan
Opt. A10	China
Opt. A11	India
Opt. A99	No power cord or AC adapter

### Language Options\*<sup>1</sup>

Option	Description
Opt. L0	English manual
Opt. L1	French manual
Opt. L2	Italian manual
Opt. L3	German manual
Opt. L4	Spanish manual
Opt. L5	Japanese manual
Opt. L6	Portuguese manual
Opt. L7	Simplified Chinese manual
Opt. L8	Traditional Chinese manual
Opt. L9	Korean manual
Opt. L10	Russian manual
Opt. L99	No manual

\*<sup>1</sup> Language options include a translated front-panel overlay for the selected language(s).

### Service Options\*<sup>2</sup>

Option	Description
Opt. C3	Calibration Service 3 years
Opt. C5	Calibration Service 5 years
Opt. CA1	Provides a single calibration event, or coverage for the designated calibration interval, whichever comes first.
Opt. D1	Calibration Data Report
Opt. D3	Calibration Data Report 3 years (with Opt. C3)
Opt. D5	Calibration Data Report 5 Years (with Opt. C5)
Opt. R5	Repair Service 5 years (including warranty)

\*<sup>2</sup> Probes and accessories are not covered by the oscilloscope warranty and service offerings. Refer to the datasheet of each probe and accessory model for its unique warranty and calibration terms.

## Recommended Probes\*<sup>4</sup>

Probe	Description
TAP1500	1.5 GHz TekVPI® active voltage probe
TAP1500X2	Bundle of two 1.5 GHz Active Probes, single ended with TekVPI Interface; Certificate of traceable calibration standard
TDP0500	500 MHz TekVPI 42 V differential probe
TDP1000	1 GHz TekVPI 42 V differential probe
TCP0030	120 MHz TekVPI 30 Ampere AC/DC current probe
TCP0150	20 MHz TekVPI 150 Ampere AC/DC current probe
TCPA300/400* <sup>3</sup>	Current measurement systems amplifier
P5200	1.3 kV, 25 MHz high-voltage differential probe
P5205* <sup>3</sup>	1.3 kV, 100 MHz high-voltage differential probe
P5210* <sup>3</sup>	5.6 kV, 50 MHz high-voltage differential probe
P5100	2.5 kV, 100x high-voltage passive probe
ADA400A* <sup>3</sup>	100x, 10x, 1x, 0.1x high-gain differential amplifier
NEX-HD2HEADER	Mictor connector breakout to 0.1 in. header pins

\*<sup>3</sup> Requires TekVPI®-to-TekProbe BNC adapter (TPA-BNC).

\*<sup>4</sup> For a full selection of probes please visit the interactive probe selector tool at [www.tek.com/probes](http://www.tek.com/probes).

## Recommended Accessories

Accessory	Description
071-1844-xx	Service Manual (English only)
SIGEXPT	NI LabVIEW SignalExpress™ Tektronix Edition Software (Full Version)
FPGAView-xx	MSO Support for Altera and Xilinx FPGAs
TPA-BNC	TekVPI-to-TekProbe BNC Adapter
TEK-USB-488	GPIO-to-USB Adapter
TLAHRA with (2) 196-3476-xx	High-impedance Adapter and Leadsets for P6516 MSO Probe
119-6827-xx	CompactFlash-to-USB Memory Card Reader
ACD4000	Soft Transit Case
HCTEK4321	Hard Transit Case (Requires ACD4000)
RM4000	Rackmount Kit
TEK-DPG	Deskew Pulse Generator
067-1686-xx	Deskew Fixture

## Warranty

Three-year warranty covering all parts and labor, excluding probes.



Product(s) are manufactured in ISO registered facilities.



Product(s) complies with IEEE Standard 488.1-1987, RS-232-C, and with Tektronix Standard Codes and Formats.









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**For Further Information.** Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit [www.tektronix.com](http://www.tektronix.com)



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